CHAPTER 3
CATCHMENT AREA TREATMENT

3.1 INTRODUCTION

The developmental activities, including hydroelectric projects, often have some impacts on natural resources. The environmental impacts of such projects together with faulty management practices, etc., ultimately lead to environmental degradation and consequently to rapid sedimentation of reservoirs. Accelerated soil erosion in the catchment areas of reservoirs and transport of detached material through the drainage network gives rise to a series of problems, notably siltation, depletion of flow capacity, steady loss of storage capacity, consistent drop in hydro-electric power generation and frequent floods. Therefore for sustainable hydropower development with least negative impact on the environment watershed management plays a pivotal role. In order to minimise the damage to the project as well as the immediate environment, the watershed management programmes involving extensive soil conservation measures in the catchment have assumed tremendous importance.

Watershed management primarily involves collection of information on a wide range of parameters of static and dynamic nature related to geology, hydrology, soil, geomorphology, topography, drainage conditions, land use / land cover, climate, etc. required for formulation of detailed and comprehensive Catchment Area Treatment (CAT) Plan. A comprehensively detailed Catchment Area Treatment Plan (CAT) should focus on:

- Mitigation measures for the erosion and landslide hazards resulting from the hydropower project activities i.e., activities in the direct impact zone (DIZ).
- The problem of silt and debris load to river from the susceptible areas of the catchment.
- Checking the sediment load from the tributaries directly discharging into the reservoir.
- Protecting the directly draining catchment from scouring / sloughing and slips.

Although the proposed Dibang Multipurpose Project is not expected to have any significant negative impacts on the environment, in the following pages measures to minimize the entry of silt in to its reservoir and enhance its life as well as for conservation of the ecosystem, are described.

3.2 CATCHMENT AREA TREATMENT

The proposed Dibang Multipurpose Project will be located on the river Dibang about 1.5 km upstream of confluence of river Dibang with river Ashu Pani in Lower Dibang Valley district of Arunachal Pradesh. The project is a storage scheme and involves construction of a 288 m high concrete gravity dam. Six Head Race Tunnels are proposed from the dam block to divert the water to power house. After generation of electricity in the underground powerhouse on the right bank of the river, the discharge will be directly led to the river through six Tail Race Tunnels. The construction of the dam will create a storage of 3748.21 Mcum corresponding to FRL of El. 545 m and will occupy 4009 ha area in 43 km reservoir length.

The Dibang catchment receives a major portion of precipitation in the form of rainfall in addition to snow at the higher reaches. Generally the factors responsible for siltation are slope, together with the surface run-off, underlying rock/soil characteristics, vegetation aspects, etc. There is dense vegetation in the immediate catchment area of the present project. The natural soil erosion activity may take place in and around the areas. A catchment area treatment plan has been formulated with the main objective of arresting soil erosion in the catchment.

The Catchment Area Treatment is extremely crucial in the context of hydropower development as the life of the reservoir depends on the nature of the catchment, underlying rock/soil type, vegetation type, drainage pattern etc. Keeping in mind the topography, soil type, climate, land use and vegetation cover in the catchment area various measures, both engineering/bio-engineering and biological, are proposed to check the soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity. The engineering measures comprise construction of check dams,

wire crates, DRSM works, contour bunding, etc., while biological measures include mainly plantation of economically and environmentally important local and exotic taxa of trees.

3.3 ESTIMATION OF SOIL EROSION

In order to formulate the treatment plan it is essential to identify areas prone/vulnerable to erosion and estimate the extent of soil erosion that is taking place in the catchment area. Various factors that are responsible for soil erosion are the drainage pattern in the area, slope, soil type and the land use/land cover, etc. which have been studied for the formulation of the catchment area treatment plan.

3.3.1 Drainage

The drainage system is the prime transport channel for the sediments as well as an important natural factor for causing land degradation. In order to prepare CAT Plan, one must understand the drainage pattern of that catchment. The river originates from the snow covered southern flank of the Himalayas close to the Tibet border at an elevation of more than 5000 m. The river Dibang cuts through deep gorges and difficult terrains in its upper reach through the mountains of the Dibang Valley and Lower Dibang Valley districts of Arunachal Pradesh. The total length of Dibang from its source to its confluence with Lohit river at Sadia in Assam is 195 km. The major tributaries of Dibang river are Mathun, Tangon, Dri, Ithun & Emra. A number of small tributaries i.e. Ahi, Airi Pani, Ilu Pani, Ashu Pani, Ephi Pani, Deo Pani etc also join the river. The important feature is that all the tributaries barring Ephi Pani & Deo Pani join Dibang in its hilly catchment. The three major tributaries viz Tangon, Dri and Mathun are almost equal in size because of which the shape of the Dibang catchment is comparatively wide in its upper reach. Drainage map of directly draining catchment is placed as Map 3.1.

3.3.2 Delineation of Watersheds and Sub-watersheds

The total catchment area of the Dibang River up to the proposed Dam site 11276 sq km. The directly draining catchment is 59811.88 ha, which constitutes the study area for CAT. The directly draining catchment

comprises of nine sub-watersheds around the proposed reservoir area from the confluence of river Tangon with river Dibang up to the Dam site. The hierarchical delineation system developed by AISLUS (AISLUS Technical Bulletin - 9) was followed for the demarcation of sub-watersheds within the study area. The codification system as given in Watershed Atlas of India (AISLUS) was followed for Dibang catchment on 1:50,000 Survey of India topographical sheets. Directly draining catchment of river Dibang divides into nine sub watersheds viz., 3A2C4, 3A2C7, 3A2D1, 3A2D2, 3A2F5, 3A2G3, 3A2G4, 3A2H2 and 3A2H3. Out of these, five viz., 3A2C4, 3A2C7, 3A2D1, 3A2D2 and 3A2F5 are on the right bank and four viz., 3A2G3, 3A2G4, 3A2H2 and 3A2H3 are on left bank. An index map of nine subwatersheds of directly draining catchment is given in Map 3.2. From the thematic maps of slope, drainage, soil, and land use, a Composite Erosion Intensity Unit (CEIU) map was prepared for each sub watershed for delineating different erosion intensity units of the sub watersheds. Areas of nine subwatersheds of directly draining catchment is given below in Table 3.1.

Table 3.1: Areas of nine subwatersheds of Directly Draining Catchment of Dibang River

Sl. No.	Subwatershed code	Area	Percentage
1	3A2C4	1318.41	2.20
2	3A2C7	786.89	1.32
3	3A2D1	15327.66	25.63
4	3A2D2	6778.89	11.33
5	3A2F5	5.15	0.01
6	3A2G3	545.40	0.91
7	3A2G4	2093.76	3.50
8	3A2H2	14844.65	24.82
9	3A2H3	18111.08	30.28
		59811.88	**100.00**

3.3.3 Slope

The slope plays a great role for the loss of soil and water from an area and thereby influences its land use capability. Together with the nature and texture of soil, it also determines the erodibility of the soils. In the directly draining catchment five slope categories were identified - Gentle (0 to 15 degrees),

Moderate (16 to 30 degrees), Moderately steep (31 to 45 degrees), Steep (46 to 60 degrees), and Very steep (> 60 degrees). The slope details of directly draining catchment are shown in Table 3.2 and slope details of nine subwatersheds are presented in Table 3.3. The slope map of directly draining catchment is placed as Map 3.3. Slope maps of nine subwatersheds of directly draining catchment are presented in Map 3.6 to 3.14.

Table 3.2 : Slope Details of Directly Draining Catchment

Sl No	Degrees	Slope type	Area	Percentage
1	0 to 15	Gentle	12285.88	20.54
2	16 to 30	Moderate	22626.56	37.83
3	31 to 45	Moderately steep	19289.88	32.25
4	46 to 60	Steep	4134.64	6.91
5	> 60	Very steep	1474.92	2.47
			59811.88	**100.00**

Table 3.3: Slope Details of nine subwatersheds of Directly Draining Catchment

Sl. No.	Subwatershed	Degrees	Slope Type	Area (ha)	Percentage
1	3A2C4	0 to 15	Gentle	111.48	8.46
		16 to 30	Moderate	519.08	39.37
		31 to 45	Moderately steep	522.36	39.62
		46 to 60	Steep	141.12	10.70
		> 60	Very steep	24.37	1.85
			Total	**1318.41**	**100.00**
2	3A2C7	0 to 15	Gentle	85.2	10.83
		16 to 30	Moderate	278.45	35.39
		31 to 45	Moderately steep	325.64	41.38
		46 to 60	Steep	87.36	11.10
		> 60	Very steep	10.24	1.30
			Total	**786.89**	**100.00**
3	3A2D1	0 to 15	Gentle	2442.44	15.93
		16 to 30	Moderate	6074.28	39.63
		31 to 45	Moderately steep	5389.72	35.16
		46 to 60	Steep	1243.92	8.12
		> 60	Very steep	177.3	1.16
			Total	**15327.66**	**100.00**
4	3A2D2	0 to 15	Gentle	1656.2	24.43
		16 to 30	Moderate	2593.72	38.26
		31 to 45	Moderately steep	2271.12	33.50
		46 to 60	Steep	212.48	3.13
		> 60	Very steep	45.37	0.67
			Total	**6778.89**	**100.00**
5	3A2F5	0 to 15	Gentle	0.04	0.78
		16 to 30	Moderate	0.2	3.88
		31 to 45	Moderately steep	4.75	92.23
		46 to 60	Steep	0.16	3.11

		> 60	Very steep	0	0.00
			Total	**5.15**	**100.00**
6	3A2G3	0 to 15	Gentle	187.36	34.35
		16 to 30	Moderate	89.52	16.41
		31 to 45	Moderately steep	222.36	40.77
		46 to 60	Steep	38.92	7.14
		> 60	Very steep	7.24	1.33
			Total	**545.4**	**100.00**
7	3A2G4	0 to 15	Gentle	167.6	8.00
		16 to 30	Moderate	721.36	34.45
		31 to 45	Moderately steep	814.6	38.91
		46 to 60	Steep	270.68	12.93
		> 60	Very steep	119.52	5.71
			Total	**2093.76**	**100.00**
8	3A2H2	0 to 15	Gentle	2168.04	14.60
		16 to 30	Moderate	4663.68	31.42
		31 to 45	Moderately steep	5335.05	35.94
		46 to 60	Steep	1678.16	11.30
		> 60	Very steep	999.72	6.73
			Total	**14844.65**	**100.00**
9	3A2H3	0 to 15	Gentle	5467.52	30.19
		16 to 30	Moderate	7686.27	42.44
		31 to 45	Moderately steep	4404.28	24.32
		46 to 60	Steep	461.84	2.55
		> 60	Very steep	91.16	0.50
			Total	**18111.07**	**100.00**
			Grand Total	**59811.88**	

3.3.4 Land Use/ Land Cover Mapping

Land use and land cover mapping of the study area was carried out by standard methods of analysis of data through remote sensing technique coupled with GIS, followed by ground truthing. Geo-coded LISS-III data on CD ROMs and hard copies on the scale 1: 50,000 (available for the year 2003) were procured for digital image processing and preparation of thematic maps. Survey of India topographic sheets 82P/5, 82P/6, 82P/9, 82P/10, 82P/11, 82P/13, 82P/14, 82P/15, 82P/16, 82O/16, 91D/1, 91D/2, 91D/3, 91D/4, 91D/6, 91D/7, 91D/8 on 1:50,000 scale were used for the preparation of the base maps. These topo sheets were also used for the delineation of sub-watersheds of the immediate catchment of the project area. The sub-watersheds were then overlaid on the drainage map and land use map for determining drainage and land use details. All the thematic maps of catchment, viz., base map, drainage map and land use / land cover map, etc.,

were then transferred to Geographic Information System (GIS) for further overlay analysis. The landuse landcover map is prepared using GIS mapping where inputs of toposheets of the catchments area and satellite imageries are used to come out with the land use / land cover pattern. The map is shown as Map 3.4.

Forest

Dibang catchment is covered by trees and other vegetation types, which are capable of producing timber and other forest produce. The vegetation are mostly of Northern Tropical Semi Evergreen and North Indian Moist Deciduous Forests. Varying degree of biotic disturbances, mainly due to traditional practice of jhuming has been experienced by few patches of forests. About 48.76 % (29163.44 ha) is dense forest whereas 12.41 % (7419.88 ha) is open forest of total directly draining catchment. In the proposed submergence area the dense mixed forest is limited along the bank of the river.

Settlement and Agriculture

The catchment is lived by rural based settlement only, except few urban areas. Mostly in these areas shifting cultivation is practiced, baring a few patches like Hunli, reach between Ambolin to Anini etc., where terracing is done.

Areas under agriculture / current jhum / habitation works out to be 6.44 % (3851.64 ha) while degraded forest / abandoned jhum works out to be 17.19 % (10281.64 ha) of total area of directly draining catchment.

Snow Covered Area

Snow covered areas constitute about 0.23 % (139.52 ha) of directly draining catchment.

Barren / Rocky Area

Rock exposures of varying lithology, often barren and devoid of soil cover and vegetation or covered with sparse vegetation, are noticed in the directly

draining catchment. They occur generally as isolated exposure. The area under this category works out to be 13.13 % (7852.32 ha).

Water Body

Water bodies, mainly comprising of river Dibang and its tributaries, constitute about 1.84 % (1103.44 ha) of total directly draining catchment.

Landuse / landcover details of directly draining catchment is shown in Table 3.4 while land use / land cover maps of different subwatersheds of directly draining catchment are presented in Map 3.6 to 3.14.

Table 3.4: Landuse Details of Directly Draining Catchment

Sl. No.	Class	Area (ha)	Percentage
1	Dense Forest	29163.44	48.76
2	Open Forest	7419.88	12.41
3	Degraded forest / Abondoned Jhum	10281.64	17.19
4	Agriculture / Current Jhum / Habitation	3851.64	6.44
5	Barren / Rocky	7852.32	13.13
6	Water Body	1103.44	1.84
7	Snow	139.52	0.23
	Total	**59811.88**	**100.00**

Table 3.5: Subwatershed wise Land use/Land cover Details

Sl. No.	Subwatershed code	EIMU	Area
1	3A2C4	Dense Forest	509.12
		Open Forest	372.38
		Degraded forest / Abondoned Jhum	185.16
		Agriculture / Current Jhum / Habitation	49.6
		Barren / Rocky	174.16
		Water Body	27.99
		Snow	0
		Total	**1318.41**
2	3A2C7	Dense Forest	199.16
		Open Forest	325.49
		Degraded forest / Abondoned Jhum	78.28

		Agriculture / Current Jhum / Habitation	35.36
		Barren / Rocky	82.36
		Water Body	65.32
		Snow	0.92
		Total	**786.89**
3	3A2D1	Dense Forest	6748.4
		Open Forest	1992.92
		Degraded forest / Abondoned Jhum	2916.51
		Agriculture / Current Jhum / Habitation	1143.64
		Barren / Rocky	2199.48
		Water Body	311.07
		Snow	15.64
		Total	**15327.66**
4	3A2D2	Dense Forest	3194.62
		Open Forest	1012.92
		Degraded forest / Abondoned Jhum	1134.64
		Agriculture / Current Jhum / Habitation	394.92
		Barren / Rocky	917.68
		Water Body	102.91
		Snow	21.2
		Total	**6778.89**
5	3A2F5	Dense Forest	0.68
		Open Forest	0
		Degraded forest / Abondoned Jhum	0.68
		Agriculture / Current Jhum / Habitation	1.16
		Barren / Rocky	1.6
		Water Body	1.03
		Snow	0
		Total	**5.15**
6	3A2G3	Dense Forest	130.08
		Open Forest	173.37
		Degraded forest / Abondoned Jhum	88.84
		Agriculture / Current Jhum / Habitation	27.4
		Barren / Rocky	78.2
		Water Body	47.51
		Snow	0
		Total	**545.4**
7	3A2G4	Dense Forest	1390.04
		Open Forest	107.76
		Degraded forest / Abondoned Jhum	280.6
		Agriculture / Current Jhum / Habitation	109.13
		Barren / Rocky	187.72

		Water Body	18.51
		Snow	0
		Total	**2093.76**
8	3A2H2	Dense Forest	6860.2
		Open Forest	1932.84
		Degraded forest / Abondoned Jhum	2746.24
		Agriculture / Current Jhum / Habitation	954.32
		Barren / Rocky	2147.7
		Water Body	199.87
		Snow	3.48
		Total	**14844.65**
9	3A2H3	Dense Forest	10131.14
		Open Forest	1502.2
		Degraded forest / Abondoned Jhum	2850.69
		Agriculture / Current Jhum / Habitation	1136.11
		Barren / Rocky	2063.42
		Water Body	329.23
		Snow	98.28
		Total	**18111.07**
		Grand Total	**59811.88**

Landuse details of submergence area are presented under Table 3.6 and Map 3.4A.

Table 3.6: Landuse of Submergence Area

Landuse class	**Area (ha)**	**Percentage**
Abondoned Jhum / Degraded forest	755.26	18.84
Current Jhum / Habitation / Settled cultivation	286.98	7.16
Dense Mixed Forest	1551.76	38.71
Open Forest	619.52	15.45
Rocky	560.42	13.98
Water Bodies	235.06	5.86
Total	**4009.00**	**100.00**

3.3.5 Soils

Soil details of directly draining area are shown in Table 3.7 whereas soil map of directly draining catchment is placed as Map 3.5.

Table 3.7: Soil Details of Directly Draining Catchment

Sl. No.	Mapping Unit (As per NBSS & LUP)	Soil Description	Association with	Erositivity	Area (ha)
1	1	Shallow, excessively drained, loamy-skeletal	Moderately deep, excessively drained on moderately steep slope	Very severe	11151.52
2	2	Deep, loamy-skeletal	Deep, somewhat excessively drained loamy skeletal on moderately steep slope	Severe	1211.68
3	3	Shallow, loamy-skeletal	Moderately deep, somewhat excessively drained on moderately steep slope	Severe	11254.12
4	4	Shallow, loamy-skeletal	Moderately deep, somewhat excessively drained on very steep slope	Severe	21553.76
5	7	Very deep, fine soils	Moderately shallow, excessively drained clayey soils on steep slope	Severe	184.64
6	9	Deep, well drained fine soils	Very deep, well-drained, fine loamy soils on moderate slope	Moderate	7371.44
7	11	Very deep, well drained, fine loamy soils	On moderate slope, very deep well drained fine soils	Moderate	3389.12
8	46	Rocky mountains covered with perpetual snow and glaciers	-	-	3695.6
				Total	**59811.88**

3.3.6 Sediment Yield Index Model

The Silt Yield Index Model developed by All India Soil & Land Use Survey (Dept of Agriculture, Govt. of India) was followed for calculating sediment yield index. The SYI model considering sedimentation as product of erosivity,

erodibility and areal extent was conceptualized in the All India Soil & Land Use Survey as early as 1969 and has been in operational use since then to meet the requirements of prioritization of smaller hydrologic units within River Valley Projects catchment areas.

The model conceptualizes sediment delivery from a hydrologic unit into a reservoir as a multiplicative function of the potential soil detachment representing the erosivity factor; the transportability of the detached material (delivery ratio) and the area of the hydrologic entity. This can be expressed as:

Sediment yield = f (Erosivity of soil x delivery ratio x area of hydrologic unit)

The erosivity is simulated with the sediment yield weightage value which is based on assessment of the composite effect of assemblage of erosivity determinants whereas, the delivery ratio is adjudged by the likely delivery of the eroded material into the reservoir.

3.3.7 Sediment Yield Weightage Value

The erosivity determinants are the soil and land attributes that have direct or reciprocal bearing on the unit of the detached soil material. The relationship can be expressed as:

Soil erosivity = f (slope, soil parameters, land use / land cover)

The functional behaviour of each of the attributes is discussed in the following paras:

(a) Slope: As the slope becomes steeper, the runoff coefficient increases, the kinetic energy and carrying capacity of the surface flow becomes greater, soil stability and as well the slope stability decreases and splash erosion increases.

(b) Land use / land cover: Covers including plant canopy, plant residues, mulches or dense growing plants greatly modify the effect of rainfall and thus affect soil erosion. The plant canopy intercepts raindrops and the water dripping of the leaves is less erosive than unhindered

raindrops. Moreover, the detachment of sediments does not occur on the portion of the covered soil surface because the drops are intercepted and there is no fall distance for drops to regain energy. The surface cover also slows down the run-off thus increasing flow depth which further decreases detachment by cushioning the impact of raindrops and reducing their hydrodynamic impact forces (Mutchler and Young, 1975).

(c) Soil parameters: The soil properties influencing erodibility include particle size distribution, organic matter content, its association with different morphological features and effective soil depth. Infiltration rate and soil permeability which is function of soil texture, coarse fragments, effective soil depth, etc. determines the quantity of surface flow. Soil erodibility is also governed by the active surface area of the soil particles. Soil structure or aggregate stability is another important factor offering resistance to soil detachment. Soil details considered for calculating / identifying erosion intensity units in the directly draining catchment have already been given under Table 3.7 and Map 3.5.

3.3.8 Delivery Ratio

Delivery ratio refers to the percent of the soil material detached from the source area reaching the reservoir through surface flow or travelling through drainage courses. Since the transport phenomenon involves suspension of the soil material and its movement over the land surface of the hydrologic unit, the delivery ratio is governed both by the soil factors affecting the dispersion value of the soils and the watershed attributes determining the flow mechanism. The transport of the suspended material is governed by number of parameters namely shape and size of the watershed, physiography and relief, drainage pattern, drainage density, stream gradient, proximity of the eroded area to the active stream or reservoir and the presence or absence of silt traps within the watershed.

3.3.9 Sediment Yield Index

The sediment Yield Index (SYI) is defined as the Yield per unit area and SYI Value for hydrologic unit is obtained by taking the weightage arithmetic mean

of the products of the weightage value and delivery ratio over the entire area of the hydrologic unit by using suitable empirical equation.

3.3.10 Prioritization of Subwatersheds

The prioritization of the hydrologic units within the vast catchments is based on the Sediment Yield Indices (SYI) of the smaller units. The subwatersheds are subsequently rated into various categories corresponding to their respective values.

3.4 METHODOLOGY FOR PRIORITIZATION

The various steps involved in the application of model are:

- Preparation of a framework of subwatersheds through systematic delineation and codification.
- Rapid reconnaissance surveys leading to the generation of a map indicating erosion-intensity mapping units (EIMUs).
- Assignment of weightage values to various mapping units based on relative silt-yield.
- Assignment of maximum delivery ratios to various erosion intensity mapping units and assessment of adjusted delivery ratios for different subwatersheds.
- Computing Silt-Yield Index for individual subwatersheds.
- Grading of subwatersheds into very severe, severe, moderate, slight and very slight priority categories.

3.5 ASSIGNMENT OF EROSIVITY WEIGHTAGE VALUE

The composite erosion-intensity mapping units were assigned relative erosivity values adjudged to be indicative of the combined effect of dynamic inter-relationship of the factors in terms of active erosivity of the units. The erosivity values were assessed as resultant of combined and reciprocal influence of a set of the factors viz., slope, land use and cover conditions, and soil characteristics.

For comparing different erosivity determinant attributed of various mapping units a statement on differentiating characteristics of the units was prepared

and the relative values assigned to different units in a rational manner. A factor k, rated as an inertia factor signifying equilibrium between erosion and sedimentation was assigned erosivity value of 10 and was taken as a standard reference for comparison and proportional additions or subtractions from this basic value in discrete numbers were made assessing the collective effect of different attributes corresponding to potential sediment yield. Any addition to this factor is indicative of erosion roughly in proportion to the added factor whereas the subtraction is suggestive of the deposition possibilities. The erosivity values ranging from 8 (k-2) to 30 (k+20) have so far been assigned to various subwatersheds.

The details of areas falling in different Erosion Intensity Mapping Units (EIMUs) in the directly draining catchment is given in Table 3.8. The erosion intensity map of directly draining catchment is placed as Map 3.15. Erosion intensity maps of different subwatersheds of directly draining catchment are presented in Map 3.6 to 3.14.

Table 3.8: EIMU Details

Sl. No.	EIMU Category	Area (ha)	Percentage
1	Very severe	419.6	0.70
2	Severe	10119.96	16.92
3	Moderate	12598.84	21.06
4	Slight	22627.94	37.83
5	Very slight	12802.58	21.40
6	Water body	1103.44	1.84
7	Snow	139.52	0.23
		59811.88	**100.00**

3.6 ASSIGNMENT OF DELIVERY RATIOS (DRS)

The delivery ratios were adjusted suitably for individual subwatersheds to account for the deposition of the detached material enroute the reservoir site. The distance of subwatershed from the reservoir site was considered as the major factor for adjusting the DR values. The criteria adopted for assigning

the delivery ratio are mentioned in Table 3.9.

Table 3.9: Delivery Ratio (DR)

Distance from Nearest stream (km)	DR values
0.00 - 0.50	0.95
0.51 - 1.00	0.90
1.01 - 1.50	0.85
1.51 - 2.00	0.75
2.00 - 2.50	0.65
2.51 - 3.00	0.55
3.01 - 3.50	0.40

3.7 COMPUTATION OF SILT YIELD INDEX

The area of each of the mapping units is computed on GIS platform and silt yield indices of individual subwatersheds were calculated using the following equation:

$$SYI = \sum \frac{(Ai \times Wi \times Di)}{Aw} \times 100; \quad i = 1 \text{ to } n$$

where

SYI = Sediment Yield Index

Ai = Area of ith mapping unit

Wi = Weightage value of ith mapping unit

Di = Adjusted delivery ratio assigned to ith mapping unit

N = No. of mapping units

Aw = Total area of subwatershed

Calculation of sediment yield index for nine subwatersheds of directly draining catchment is shown in Table 3.10.

Table 3.10: Calculation of Sediment Yield Index

Sl. No.	Subwatershed code	EIMU	Area	Weightage	Area x Weightage	Delivery Ratio	Gross sediment yield	Sediment yield index
1	3A2C4	Very severe	2.00	25	50.00	0.95	47.50	-
		Severe	153.84	21	3230.64	0.90	2907.58	-
		Moderate	259.44	18	4669.92	0.80	3735.94	-
		Slight	641.60	15	9624.00	0.70	6736.80	-
		Very slight	233.54	12	2802.48	0.60	1681.49	-
		Water body	27.99	0	0.00	0.00	0.00	-
		Snow	0.00	0	0.00	0.00	0.00	-
			1318.41				**15109.30**	**1146.02**
2	3A2C7	Very severe	2.16	25	54.00	0.95	51.30	-
		Severe	78.96	21	1658.16	0.90	1492.34	-
		Moderate	119.88	18	2157.84	0.80	1726.27	-
		Slight	464.09	15	6961.35	0.70	4872.95	-
		Very slight	55.56	12	666.72	0.60	400.03	-
		Water body	65.32	0	0.00	0.00	0.00	-
		Snow	0.92	0	0.00	0.00	0.00	-
			786.89				**8542.89**	**1085.65**
								-
3	3A2D1	Very severe	94.12	25	2353.00	0.95	2235.35	-
		Severe	3235.72	21	67950.12	0.90	61155.11	-
		Moderate	3255.64	18	58601.52	0.80	46881.22	-
		Slight	5988.55	15	89828.25	0.70	62879.78	-

		Very slight	2426.92	12	29123.04	0.60	17473.82	-
		Water body	311.07	0	0.00	0.00	0.00	-
		Snow	15.64	0	0.00	0.00	0.00	-
			15327.66				**190625.27**	**1243.67**
								-
4	3A2D2	Very severe	1.24	25	31.00	0.95	29.45	-
		Severe	987.56	21	20738.76	0.90	18664.88	-
		Moderate	1458.88	18	26259.84	0.80	21007.87	-
		Slight	1693.68	15	25405.20	0.70	17783.64	-
		Very slight	2513.42	12	30161.04	0.60	18096.62	-
		Water body	102.91	0	0.00	0.00	0.00	-
		Snow	21.20	0	0.00	0.00	0.00	-
			6778.89				**75582.47**	**1114.97**
								-
5	3A2F5	Very severe	0.00	25	0.00	0.95	0.00	-
		Severe	1.08	21	22.68	0.90	20.41	-
		Moderate	2.36	18	42.48	0.80	33.98	-
		Slight	0.68	15	10.20	0.70	7.14	-
		Very slight	0.00	12	0.00	0.60	0.00	-
		Water body	1.03	0	0.00	0.00	0.00	-
		Snow	0.00	0	0.00	0.00	0.00	-
			5.15				**61.54**	**1194.87**
								-
6	3A2G3	Very severe	1.24	25	31.00	0.95	29.45	-
		Severe	72.80	21	1528.80	0.90	1375.92	-
		Moderate	125.08	18	2251.44	0.80	1801.15	-
		Slight	173.21	15	2598.15	0.70	1818.71	-

		Very slight	125.56	12	1506.72	0.60	904.03	-
		Water body	47.51	0	0.00	0.00	0.00	-
		Snow	0.00	0	0.00	0.00	0.00	-
			545.40				**5929.26**	**1087.14**
								-
7	3A2G4	Very severe	42.24	25	1056.00	0.95	1003.20	-
		Severe	329.40	21	6917.40	0.90	6225.66	-
		Moderate	321.84	18	5793.12	0.80	4634.50	-
		Slight	1188.29	15	17824.35	0.70	12477.05	-
		Very slight	193.48	12	2321.76	0.60	1393.06	-
		Water body	18.51	0	0.00	0.00	0.00	-
		Snow	0.00	0	0.00	0.00	0.00	-
			2093.76				**25733.46**	**1229.05**
								-
8	3A2H2	Very severe	270.88	25	6772.00	0.95	6433.40	-
		Severe	2921.32	21	61347.72	0.90	55212.95	-
		Moderate	3477.84	18	62601.12	0.80	50080.90	-
		Slight	6388.20	15	95823.00	0.70	67076.10	-
		Very slight	1583.06	12	18996.72	0.60	11398.03	-
		Water body	199.87	0	0.00	0.00	0.00	-
		Snow	3.48	0	0.00	0.00	0.00	-
			14844.65				**190201.38**	**1281.28**
								-
9	3A2H3	Very severe	5.72	25	143.00	0.95	135.85	-
		Severe	2339.28	21	49124.88	0.90	44212.39	-
		Moderate	3577.88	18	64401.84	0.80	51521.47	-
		Slight	6089.64	15	91344.60	0.70	63941.22	-

		Very slight	5671.04	12	68052.48	0.60	40831.49	-
		Water body	329.23	0	0.00	0.00	0.00	-
		Snow	98.28	0	0.00	0.00	0.00	-
			18111.07				**200642.42**	**1107.84**

3.8 PRIORITIZATION OF SUBWATERSHEDS

The gradation and assignment of priority ratings to the subwatersheds are based on the descending values of SYI values. As per the methodology of priority delineation of AISLUS the priority categories that have been classified based on the SYI values, are given in Table 3.11:

Table 3.11: Relation of Priority Categories and SYI Values

S. No.	Priority Category	SYI values
1	Very high	> 1300
2	High	1200 - 1299
3	Medium	1100 - 1199
4	Low	1000 - 1099
5	Very low	< 1000

SYI values assigned to nine subwatersheds of directly draining catchment is given below in Table 3.12

Table 3.12: SYI Values assigned to different subwatersheds

S. No.	Subwatershed	SYI value
1	3A2C4	1146
2	3A2C7	1086
3	3A2D1	1244
4	3A2D2	1115
5	3A2F5	1195
6	3A2G3	1087
7	3A2G4	1229
8	3A2H2	1281
9	3A2H3	1108

Based on the above criterion of AISLUS following priority categories in Table 3.13 have been assigned to the nine subwatersheds of directly draining catchment:

Table 3.13: Priority ranking assigned to different subwatersheds

S. No.	Priority ranking	SYI value	Priority
1	3A2H2	1281	High
2	3A2D1	1244	High
3	3A2G4	1229	High
4	3A2F5	1195	Medium
5	3A2C4	1146	Medium
6	3A2D2	1115	Medium
7	3A2H3	1108	Medium
8	3A2G3	1087	Low
9	3A2C7	1086	Low

3.9 AREA IDENTIFIED FOR CAT

For the catchment area treatment areas falling under very severe and severe erosion intensity categories i.e., 10539.56 ha will be required for treatment. The subwatersheds to be taken first and thereafter should be as per the above priority ranking. Various engineering and bioengineering measures like brushwood check dams, contour bunding, gabion structures, loose boulder check dams and silt retention dams are suggested for the very severe and severe erosion intensity areas. In addition, biological measures like plantation of shrubs and trees are also suggested for these areas.

In the upper catchment of the subwatersheds brushwood check dams are proposed to control the erosion in the first order basin. The whole length of the streams are segmented into 50 m interval and depending upon the gradient a total of 1276 brushwood check dams are proposed. In first order basin in the lower reaches, where discharge is higher and valley length is less, at 30 m intervals loose boulder check dams are proposed. Therefore, a total of 768 loose boulder check dams are proposed. In those areas where discharge is much higher, 259 gabion structures are proposed. In those areas where erosion intensity is severe and very severe countour bunding is proposed. Therefore, a total of 82 contour bunding will be constructed. In third order and more than third order basin 124 silt retention dams are proposed. It is seen that about 12 % and 18 % of the area are composed of open forest

and degraded forest / abandoned jhum, respectively. Therefore, about 12 % of the total area of subwatershed shall be treated by means of plantation.

3.10 PERIOD AND SCHEDULE OF IMPLEMENTATION

The plan needs to be implemented in a phased manner so as to attain the goals set successfully. Keeping in view the local topography and climate, it is proposed to complete the CAT programme in five years (Table 3.14). The year wise break-up of the CAT work in different subwatersheds is given in Table 3.15 to 3.23 and Maps 3.16 to 3.24.

Table 3.14: Details of the Engineering and biological works to be undertaken under CAT Plan for the Dibang Multipurpose project

S. No	Subwa-tershed	Brush wood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1	**3A2C4**	24	0	0	18	0	10
2	**3A2C7**	12	0	0	0	0	6
3	**3A2D1**	402	24	80	242	40	244
4	**3A2D2**	118	10	28	70	14	72
5	**3A2F5**	2	2	1	0	0	1
6	**3A2G3**	8	0	0	0	0	6
7	**3A2G4**	48	2	16	36	2	26
8	**3A2H2**	384	26	76	230	38	232
9	**3A2H3**	278	18	58	172	28	173
	Total	**1276**	**82**	**259**	**768**	**124**	**770**

Table 3.15: Year-wise Treatment of subwatershed 3A2C4 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	4	0	0	2	0	2
2nd	6	0	0	6	0	2
3rd	6	0	0	4	0	3
4th	4	0	0	6	0	2
5th	4	0	0	0	0	1
Total	**24**	**0**	**0**	**18**	**0**	**10**

Table 3.16: Year-wise Treatment of subwatershed 3A2C7 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	2	0	0	0	0	1
2nd	2	0	0	0	0	1
3rd	4	0	0	0	0	2
4th	4	0	0	0	0	1
5th	0	0	0	0	0	1
Total	**12**	**0**	**0**	**0**	**0**	**6**

Table 3.17: Year-wise Treatment of subwatershed 3A2D1 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	80	2	12	40	6	38

2nd	110	6	20	54	16	48
3rd	120	8	20	60	10	75
4th	62	4	16	52	6	53
5th	30	4	12	36	2	30
Total	**402**	**24**	**80**	**242**	**40**	**244**

Table 3.18: Year-wise Treatment of subwatershed 3A2D2 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	24	0	4	12	2	11
2nd	32	4	8	16	4	14
3rd	36	4	6	18	4	22
4th	18	2	4	14	4	16
5th	8	0	6	10	0	9
Total	**118**	**10**	**28**	**70**	**14**	**72**

Table 3.19: Year-wise Treatment of subwatershed 3A2F5 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	0	0	0	0	0	1
2nd	2	0	1	0	2	0
3rd	0	2	0	0	0	0
4th	0	0	0	0	0	0
5th	0	0	0	0	0	0
Total	**2**	**2**	**1**	**0**	**2**	**1**

Table 3.20: Year-wise Treatment of subwatershed 3A2G3 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	2	0	0	0	0	1
2nd	2	0	0	0	0	1
3rd	4	0	0	0	0	2
4th	0	0	0	0	0	1
5th	0	0	0	0	0	1
Total	**8**	**0**	**0**	**0**	**0**	**6**

Table 3.21: Year-wise Treatment of subwatershed 3A2G4 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	8	0	4	6	0	4
2nd	12	0	4	8	0	5
3rd	14	2	4	8	2	8
4th	8	0	4	8	0	6
5th	6	0	0	6	0	3
Total	**48**	**2**	**16**	**36**	**2**	**26**

Table 3.22: Year-wise Treatment of subwatershed 3A2H2 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	76	4	12	38	4	36
2nd	106	6	20	52	14	46

3rd	114	8	18	56	10	71
4th	60	4	14	50	6	51
5th	28	4	12	34	4	28
Total	**384**	**26**	**76**	**230**	**38**	**232**

Table 3.23: Year-wise Treatment of subwatershed 3A2H3 of Dibang Multipurpose Project

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	54	2	8	28	4	27
2nd	78	4	14	38	10	34
3rd	82	6	14	44	8	53
4th	44	4	12	36	4	38
5th	20	2	10	26	2	21
Total	**278**	**18**	**58**	**172**	**28**	**173**

The prioritization of sub-watersheds for treatment measures has been done with particular reference to the silt yield index and proximity with the reservoir rim. The areas showing severe erosion intensity in all subwatersheds, especially those located in the vicinity of the reservoir must be taken on priority basis for the treatment programme. Shrubs and trees to be planted under biological interventions have to be reared in the nursery to be created for this purpose. No separate nursery is proposed for the CAT Plan as the one proposed for Compensatory Afforestation Plan will serve the requirements of the plans. The cost estimates for the creation and maintenance of the plant nursery are given in the budget estimate for the Biodiversity Conservation Plan. The year wise break up of the specific work to be undertaken in different sub-watersheds is given in Table 3.24.

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Table 3.24: Year wise break up of the work to be done under CAT Plan

Year	Brushwood check Dam (Nos.)	Contour bunding (Nos.)	Gabion Structure (Nos.)	Loose Bolder Check Dam (Nos.)	Silt Retention Dam (Nos.)	Plantation (ha)
1st	250	8	40	126	16	121.00
2nd	350	20	67	174	46	151.00
3rd	380	30	62	190	34	236.00
4th	200	14	50	166	20	168.00
5th	96	10	40	112	8	94.00
Total	1276	82	259	768	124	770.00

3.11 DETAILS OF TREATMENT MEASURES WITH UNIT COST ESTIMATE

Various engineering and biological measures as proposed above are elaborated below. The details of cost as well as the type of work along with rate, quantity, etc are given in Tables 3.24 to 3.25. The unit cost of the engineering measures is as per the CPWD gazette (reference number S/O/R 1:1 2004-2005). For the biological measures the unit cost for plantation is based on the Forest Department, Govt. of Arunachal Pradesh's notification no. FOR-01-42/Cons/2002/16, 128-188 T dated 30.06.2003.

3.11.1 Silt Retention Dams

Silt Retention Dam is a concrete structure which constitutes of spillway in one side and diversion in the other side. This kind of structure is useful for retaining the silt where discharge is more and the slope is moderate around 10^0 to 25^0. Normally a free board of 0.5 m is provided and the cost estimation and dimensions of a typical Silt Retention Dam is provided below-

Unit Cost Estimation of Silt Retention Dam

- ✓ Depth of foundation = 1.5 mtrs
- ✓ Height of Dam = 3mts from bed level
- ✓ Top width = 1.5 mtrs

- ✓ Bottom width = 5.5 mtrs

Table 3.25: Unit Cost of Silt retention Dam

Sl. No.	Particulars	Quantity	Units	Rate per unit (Rs.)	Total Amount (Rs.)
1	Earth works	15	m^3	40.00	600.00
2	Cement	180	bags	225.00	40,500.00
3	Steel	20	Quintals	2445	48,900.00
Total Cost					90,000.00

3.11.2 Contour bunding

Contour bunding in shallow and medium soil at appropriate vertical interval and horizontal distance across the slopes helps in reduction of soil erosion and conservation of moisture. It consists of constructing narrow based trapezoidal bunds on contours to improve runoff rainwater in such a manner that it percolates and recharges the root profile on either side of the bunds up to 50 to distance between two such terraces

Unit Cost Estimation for Contour Bunding

Item no. 1- Earth work in excavation for trenches

- ➢ Up to a depth of 2.00 m below the existing ground level
- ➢ In ordinary soil, 10.00 x 0.60 x 1.00 = 6.00 m^3

(Fig. 3.1)

Hence at the @ Rs. 53.40/ m^3 **Rs. 320.40 /-**

Item no. 2- Earth /sand filling in plinth in layers not more than 150 mm thick including necessary carriage

- ➢ With earth or silt or sand obtained by head load with lead up to 90m and lift upto 2.0 m 1 x 10.00 x 0.60 x 1.00 = 6.00 m^3

Hence at the @ Rs. 39.60/ m^3 **Rs. 237.60 /-**

Total = Rs. 558.00/- (Rupees Five hundred fifty eight only)

Illustration of countour bund is presented as Fig. 3.1.

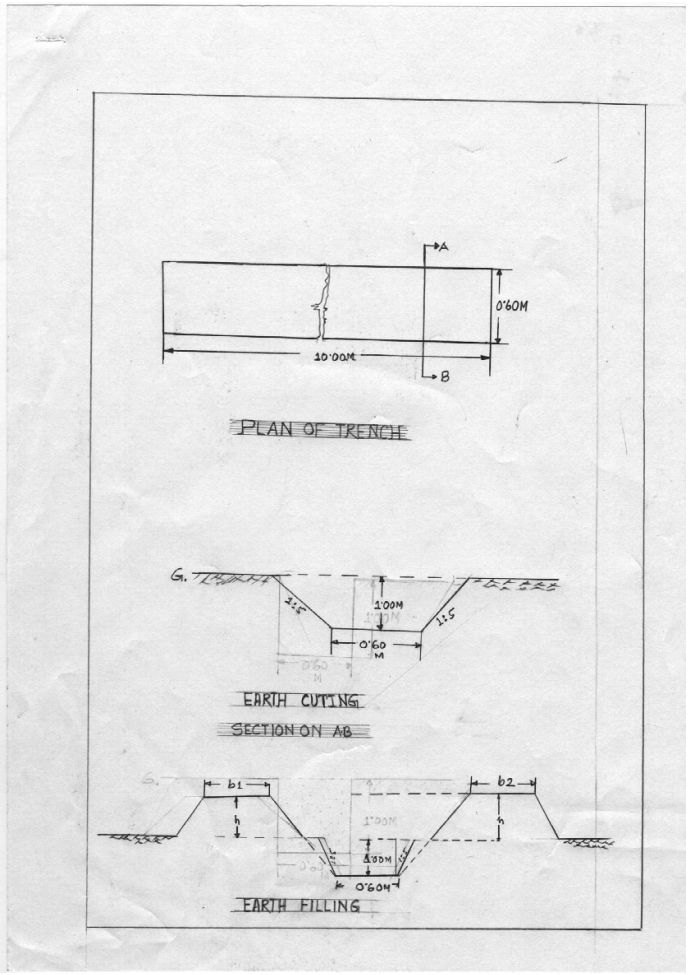

Fig. 3.1: Schematic representation of Countour Bund

3.11.3 Brush Wood Check Dams

Gullies are mainly formed on account of physiography, soil type and heavy biotic interferences in an area. The scouring of streams at their peak flows and sediment laden run-off cause gullies. Narrow gully can be treated with brush wood check dams or plots to control gully erosion. Brushwood will be available locally in abundance. The construction will be faster and the catchment can be protected from gulley erosion. Subsequently this will help in reducing sedimentation in the reservoir.

Before commencing the construction for the check dam, the sides of the gully

at the selected sites are slopped to 1:1.5 and the gully bottom, for the whole length of the dam, is lowered by about 15 cm. Also, 15 cm excavations are carried up into the bank as high as required to give the necessary notch capacity for discharging the run-off. The country wood stakes, about 10 cm to 13 cm in diameter are driven 0.90 m apart in two rows to go at least 0.90 m to 1.2 metre in to the hard bed of gully. The distance between the rows will be 0.9 m. The tops of the stakes are kept at such a height as to form a distinct depression in the middle to form a notch of the required waterway to enable the maximum run-off to discharge. The first layer of straw and brushwood is laid across the gully between two rows of wood stakes. Over it long branches of specially selected species are laid lengthwise of the gully and well pressed. The process is repeated till the required height is obtained. The brush is anchored on to the stakes by means of galvanised iron wire. Intermediate stakes of shorter lengths are driven and the brush is anchored on to them to prevent lifting form bed by water. Drawing of a typical Double Row Brush wood Dam is presented in fig no- 3.15. Cost estimation for the Brushwood Check Dam is placed below Table 3.28.

Table 3.26: Unit Cost of Brushwood Check Dam

Particulars	Item	Quantity	Rate (Rs.)	Unit	Amount (Rs.)
Survey & Alignment		1	100	Bund	100
Purchase & Transport of Wooden Pegs (size-5 cm diameter 65 cm length)	44A	10	16	Nos	160
Construction of Bund by fixing wood pegs At dist. 20 cm in 2 rows & supporting soil & murum	45	10	16	Nos.	160
Plantation of Bushes at distance of 0.5 m		2	25	bush	50
Plantation of trees at distance of 2.5 m		1	50	Plants	50

Intercultivation 3 times		9	5	Plants	45
Total					**565.00**
Contingencies 2 %					11.30
Grand Total					**576.30 Say, 580.00**

3.11.4 Loose Bolder Check Dam

Like brushwood check dam, loose boulder check dams can be made of boulder piled up across the gulley if they are locally available. Such structures for damming a gulley or a stream to refine the flow velocity are called loose bolder check dams.

The site where the dam is to be erected is cleared and the sides are sloped to 1:1.5. The bed of the gully is excavated to a uniform depth of 0.30 m and the dry boulders are packed over pressed straw from that level. In the centre of the dam portion sufficient waterway is allowed to discharge the maximum run-off from the catchment. The boulder filling should go up to 0.30 m to 0.60 m into the stable portion of the gully side to prevent end cutting. In the rear sufficient length (0.90 m) and width of apron has to be in the following table 3.29 cost estimation for loose boulder check dam is presented:

Table 3.27: Unit Cost of Loose Boulder Check Dam

Particulars	Quantity	Unit	Rate (Rs.)	Amount (Rs.)
Survey & Alignment	1	per bund	10	10.00
Excavation on both banks	19.6	cu.m	23.5	460.60
Excavation for foundation	9.18	cu.m	23.5	215.73
Bund construction, collection of dry rubble	36.25	cu.m.	35.25	1277.81
Foundation for pitching	2.94	cu.m.	23.5	69.09
Pitching on both Banks	10.9	sq.m	41.15	448.53

Transportation charge for dry rubble	18.12	cu.m.	70.98	1286.16
Galvanized wire mesh 15 X 15 cm wire mash having 3 mm diameter	150	sq.m	60	9000.00
Transportation of wire mesh up to 50 km	1	Rs. /total Mesh	150	150.00
Survey during construction	1	Per bund	100	100.00
Total				**13017.92**
Contingencies 2 %				260.36
Grand Total				**13278.28 Say, 13278.00**

provided to prevent scour. The thickness of apron packing should not be less than 0.45 m and gully sides above apron have to be protected with stone pitching to a height of at least 0.30 m above the anticipated maximum water level to prevent side scouring. The boulders should be properly packed and may be supported on the downstream side by putting few post.

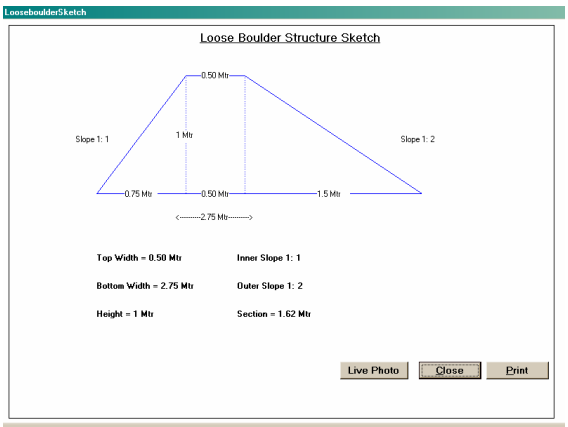

Fig. 3.2: Schematic and pictorial representation of loose boulder check dam

It may be kept in mind that the stability of these structures is basically due to the weight of the materials i.e. boulders. As the boulders are easily available

in the streams/rivulets, such structures can easily be constructed.. Schematic view of a typical loose boulder dam is presented in Fig. 3.2 & 3.3.

3.11.5 Gabion Structures

If loose boulders are considered not to be stable in a particular reach of the stream, Gabion structure or stone masonry structures can be installed. This is not very much encouraged because the terrain is stiff and the cement has to be carried by human labour. Carrying the cement will be tedious, time consuming and some times cement itself can set damaged during the carriage or while it is stocked at site for use. Therefore with proper judgement about the site conditions these structures may be installed. Cost estimates for the gabion structure construction is given in the following Table 3.30.

Table 3.28: Unit Cost of Gabion Structure

Sl. No.	Work Particulars	Item	Unit	Rate	Amount
A	Soil Work				
1	Survey Alignment		per bund	80	80
2	Excavation for foundation up to 0.30 m.	A2	cu.m.	100	100
B	Stone Work Below Foundation				
1	Refilling of foundation with dry rubble	35	cu.m.	95	3325
2	To collect dry rubble	45	cu.m.	75	3375
C.	Stone Working above foundation				
1	Work to collect & supply dry dubble	35	cu.m.	62	2170
2	Transporation of dry rubble	35	cu.m.	60	2100
3	Construction wages	35	cu.m.	120	4200
4	Stone Header	15	unit	99.5	1492.50
D	Plantation work				
1	Bush plantation	20	Plants	25	500
2	Weeding and soil work (intercultivation)	20	Plants	12	240

	Total				17582.5
	Contingencies 2 %				355
	Grand Total				**17937.50 Say, 17937.00**

3.11.6 Biological Measures

In order to help reduce the erosion of soil and its transport to the reservoir it is suggested to undertake plantation of shrubs as well as trees, wherever the soil characteristics permit, in the various subwatersheds. The best policy would be to use following local shrubs and trees, especially *Rosa webbiana,*, *Macaranga denticulata*, *Salix* sp., *Populus* sp., *Prunus armenacia, Ailanthus grandis, Altingia excelsa, Manglietia insignis, Amoora wallichi, Syzygium sp. Terminalia myriocarpa, Duabanga grandiflora, Toona febrifuga* etc. Besides these species, the rare and endangered species that are found in the project area like *Aconitum ferox* Wallich, *Actinodaphne lanata* Meissn., *Coelogyne mossiae* Rolfe, *Dendrobium aurantiacum* Reichb. *f*. *Paphiopedilum fairieanum* (Lindl.) Stein, *P. venustum* Pfitz., *Syzygium manii* (King) N. P. Balakrishnan and *Vanda coerulea* Griff. *ex* Lindl. will be planted under CAT for their ex-situ conservation and propagation. This would also help overcome the human interference that might occur during the project construction. In the villages that will get affected by the acquisition of land for different project activities provision would also be made for raising horticultural plantation like apricot, pineapples etc. The activity will be taken up on available suitable land in the villages to boost the economy of the locals. A total of 770 ha of land are proposed to be planted by different plant species as mentioned above.

3.12 ADMINISTRATIVE CHARGES

An amount of Rs. 80 lakhs will be required to be kept under this head for salary and related activities like engagement of staff on contractual basis to perform specialised activities like salary, draftmanship etc.

3.13 ADMINISTRATIVE SETUP

The catchment area treatment project involves intensive and highly technical

operations, which require the expertise of technical personnel. It is therefore recommended that the existing forest staff of Dibang Forest Division and Anini Social Forestry Division may look after all the works to be carried out under the CAT plan including plantation and maintenance as all the area to be covered under CAT plan falls under both Dibang Forest Division and Anini Social Forestry Division.

3.14 CONTINGENCY CHARGES

This Component will take care of future wage hike, unseen expenses, overflow of other components and other contingencies during implementation. An amount of Rs. 64.81 lakhs has been kept for this purpose.

3.15 MONITORING, EVALUATION AND MAINTENANCE

Monitoring and evaluation will be done as an inbuilt part of the project management. It is most important for assessing the works carried out and the results achieved vis-à-vis eco-restoration, etc. Annual work plan for each range would be prepared well in advance specifying physical and financial targets, sites, locations and beneficiaries of each component of the project activity. Month-wise work schedule of various items of each component for the financial year would also be prepared in advance and its timely implementation would be ensured. The monitoring committee proposed in Chapter-17 (Environmental Monitoring), would monitor the quality and quantity of works carried out under the CAT program.

A sum of Rs. 100 lakhs will be required to be provided for monitoring and evaluation. Under this component, independent agencies /consultants will be engaged to make base line survey, mid-term survey and end of the project survey to find out effectiveness of CAT plan activities in the catchment area. Silt load and run-off rate also will be monitored at practically feasible strategic points.

3.16 COST ESTIMATE

The total expenditure on the catchment area treatment plan to be implemented over a period of five years is estimated to be Rs. 568.11 lakhs.

The details are of cost are presented in Tables 3.29 and 3.30

Table 3.29: Sub watershed wise break-up of cost estimate on CAT Plan

(Rs. In lakhs)

S. No	Sub - watershed	Brushwood check Dam (@ Rs. 580/dam)	Contour bunding (@ Rs. 558/bund)	Gabion Structure (@ Rs. 17937/ structure)	Loose Bolder Check Dam (@ Rs. 13278/dam)	Silt Retention Dam (@ Rs. 90000/ dam)	Plantation (@Rs. 38990/ha)
1	**3A2C4**	0.14	0.00	0.00	2.39	0.00	3.90
2	**3A2C7**	0.07	0.00	0.00	0.00	0.00	2.34
3	**3A2D1**	2.33	0.13	14.35	32.13	36.00	95.14
4	**3A2D2**	0.68	0.06	5.02	9.29	12.60	28.07
5	**3A2F5**	0.01	0.01	0.18	0.00	0.00	0.39
6	**3A2G3**	0.05	0.00	0.00	0.00	0.00	2.34
7	**3A2G4**	0.28	0.01	2.87	4.78	1.80	10.14
8	**3A2H2**	2.23	0.15	13.63	30.54	34.20	90.46
9	**3A2H3**	1.61	0.10	10.40	22.84	25.20	67.45
	Total	**7.40**	**0.46**	**46.46**	**101.98**	**111.60**	**300.22**
					Grand Total		**568.11**

Table 3.30: Year-wise estimate of costs on different treatment works

Year No.	Brush wood check Dam (Nos.)	Unit Rate (Rs.)	Cost (Lakhs)	Contour bunding (Nos.)	Unit Rate (Rs.)	Cost (Lakhs)	Gabion Structure (Nos.)	Unit Rate (Rs.)	Cost (Lakhs)	Loose Bolder Check Dam (Nos.)	Unit Rate (Rs.)	Cost (Lakhs)	Silt Retention Dam (Nos.)	Unit Rate (Rs.)	Cost (Lakhs)	Plantation (ha)	Unit Rate (Rs.)	Cost (Lakhs)	Total Cost (Lakhs)
1st	250	580.00	1.45	8	558.00	0.04	40	17937.00	7.17	126	13278.00	16.73	16	90000.00	14.40	121	38990.00	47.18	**86.98**
2nd	350	580.00	2.03	20	558.00	0.11	67	17937.00	12.02	174	13278.00	23.10	46	90000.00	41.40	151	38990.00	58.87	**137.54**
3rd	380	580.00	2.20	30	558.00	0.17	62	17937.00	11.12	190	13278.00	25.23	34	90000.00	30.60	236	38990.00	92.02	**161.34**
4th	200	580.00	1.16	14	558.00	0.08	50	17937.00	8.97	166	13278.00	22.04	20	90000.00	18.00	168	38990.00	65.50	**115.75**
5th	96	580.00	0.56	10	558.00	0.06	40	17937.00	7.17	112	13278.00	14.87	8	90000.00	7.20	94	38990.00	36.65	**66.51**
Total	**1276**	**580.00**	**7.40**	**82**	**558.00**	**0.46**	**259**	17937.00	**46.46**	**768**	13278.00	**101.98**	**124**	**90000.00**	**111.60**	**770**	**38990.00**	**300.22**	**568.11**

3.17 TOTAL COST OF CAT

Total cost of CAT is given below in Table 3.31:

Table 3.31: Total cost of Catchment Area Treatment

S. No.	Particulars	Cost (Rs. in lakhs)
1	CAT Measures	568.11
2	Administrative Charges, salaries etc. for 5 years	80.00
	Subtotal	**648.11**
3	Contingency Charges 10% of above	64.81
4	Monitoring & Evaluation including maintenance for 3 years	100.00
	Total	**812.92** **Say 813 lakhs**

Note: The jeeps proposed in the Biodiversity Conservation & Management Plan shall be used for the implementation of CAT plan also.